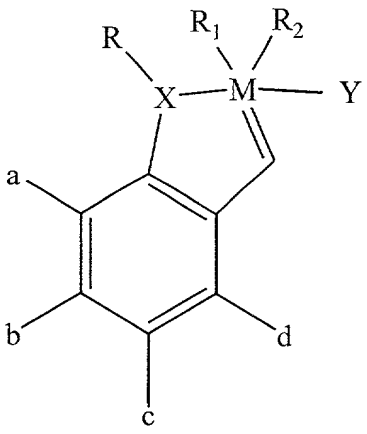
What is claimed is:

1. A composition comprising a transition metal catalyst having the following structure:



wherein:

M comprises a transition metal;

R comprises an alkyl, alkenyl, alkynyl, aryl, alkoxy, alkenyloxy, alkynyloxy, aryloxy, alkoxy carbonyl, alkylamino, alkylthio, alkylsulfonyl, alkylsulfinyl; each optionally substituted with an alkyl, halogen, alkoxy, aryl or heteroaryl moiety;

R_1 and R_2 each comprises, or together comprise, an electron withdrawing anionic ligand;

a, b, c, and d each comprises H, a halogen atom or an alkyl, alkenyl, alkynyl, aryl, alkoxy, alkenyloxy, alkynyloxy, aryloxy, alkoxycarbonyl, alkylamino, alkylthio, alkylsulfonyl; alkylsulfinyl; each optionally substituted with an alkyl, halogen, aryl or heteroaryl moiety; and

Y comprises an electron-donating heterocyclic carbene ligand.

2. The composition of claim 1 wherein M is Ru.

3. The composition of claim 1 wherein X is O.

4. The composition of claim 1 wherein R is a lower alkyl group.

5. The composition of claim 4 wherein R is isopropyl.

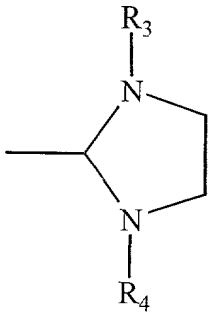
6. The composition of claim 1 wherein R_1 and R_2 each is a halogen.

7. The composition of claim 6 wherein R_1 and R_2 each is Cl.

8. The composition of claim 1 wherein a, b, c, and d each comprises H or a lower alkyl group.

9. The composition of claim 1 wherein Y comprises a 4,5-dihydroimidazol-2-ylidene.

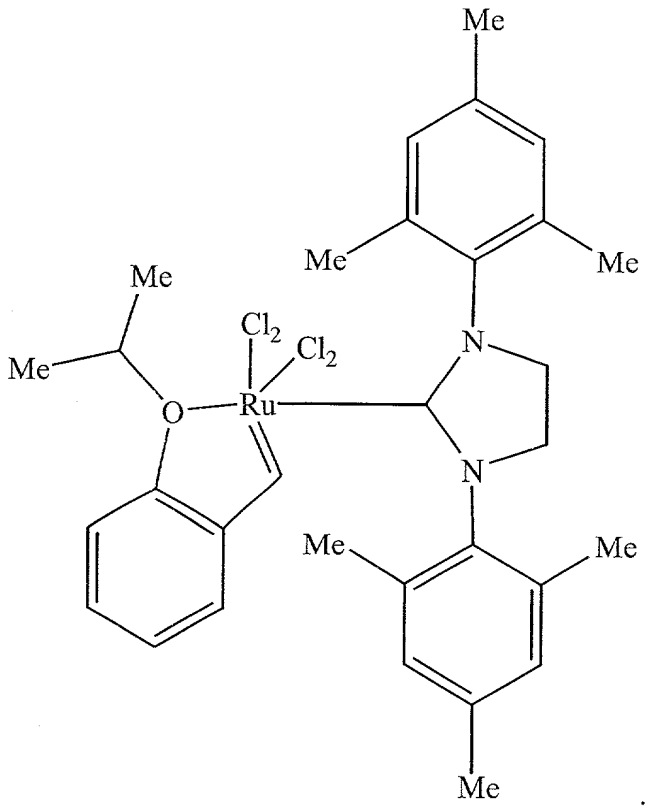
10. The composition of claim 9 wherein Y comprises a tricyclic aromatic ring structure having the following structure:



wherein R_3 and R_4 each comprises an aromatic ring moiety.

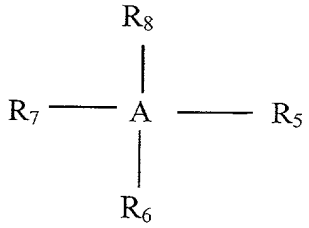
11. The composition of claim 10 wherein R_3 and R_4 comprise both comprise 2,4,6-trimethylphenyl (mesityl) moieties.

12. The composition of claim 1 comprising the following structure:



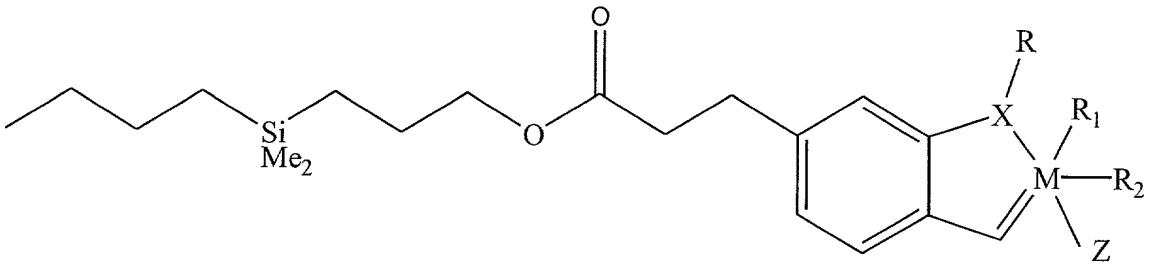
13. A composition of claim 1 wherein the transition metal catalyst is part of a dendrimer compound.

14. The transition metal catalyst of claim 13 having the following structure:



wherein A is a polyvalent atom selected from the group consisting of carbon, nitrogen, silicon and phosphorous;

R_5, R_6, R_7 and R_8 each comprises the follwing structure:



wherein:

M comprises a transition metal;

X comprises O, S, N or P;

R comprises an alkyl, alkenyl, alkynyl, aryl, alkoxy, alkenyloxy, alkynyloxy, aryloxy, alkoxy carbonyl, alkylamino, alkylthio, alkylsulfonyl, alkylsulfinyl; each optionally submitted with an alkyl, halogen, aryl or heteroaryl moiety;

R_1 and R_2 each comprises, or together comprise, an electron withdrawing group; and

Z comprises Y or a phosphine group.

15. The composition of claim 14 wherein A is silicon.

16. The composition of claim 14 wherein M is a transition metal.

17. The compositon of claim 14 wherein M is ruthenium

18. The composition of claim 14 wherein X is O.

19. The composition of claim 14 wherein R is a lower alkyl group.

20. The composition of claim 19 wherein R is isopropyl.

21. The composition of claim 14 wherein R_1 and R_2 each is a halogen.

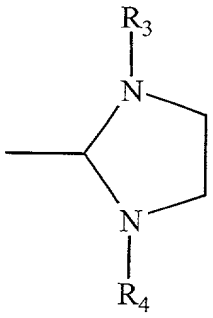
22. The composition of claim 21 wherein R_1 and R_2 each is Cl.

23. The composition of claim 14 wherein Z comprises a phosphine moiety having the formula $P(Cy)_3$.

24. The composition of claim 23 wherein Cy comprises an aliphatic ring structure.

25. The composition of claim 23 wherein Cy comprises a cyclohexyl or cyclopentyl group.

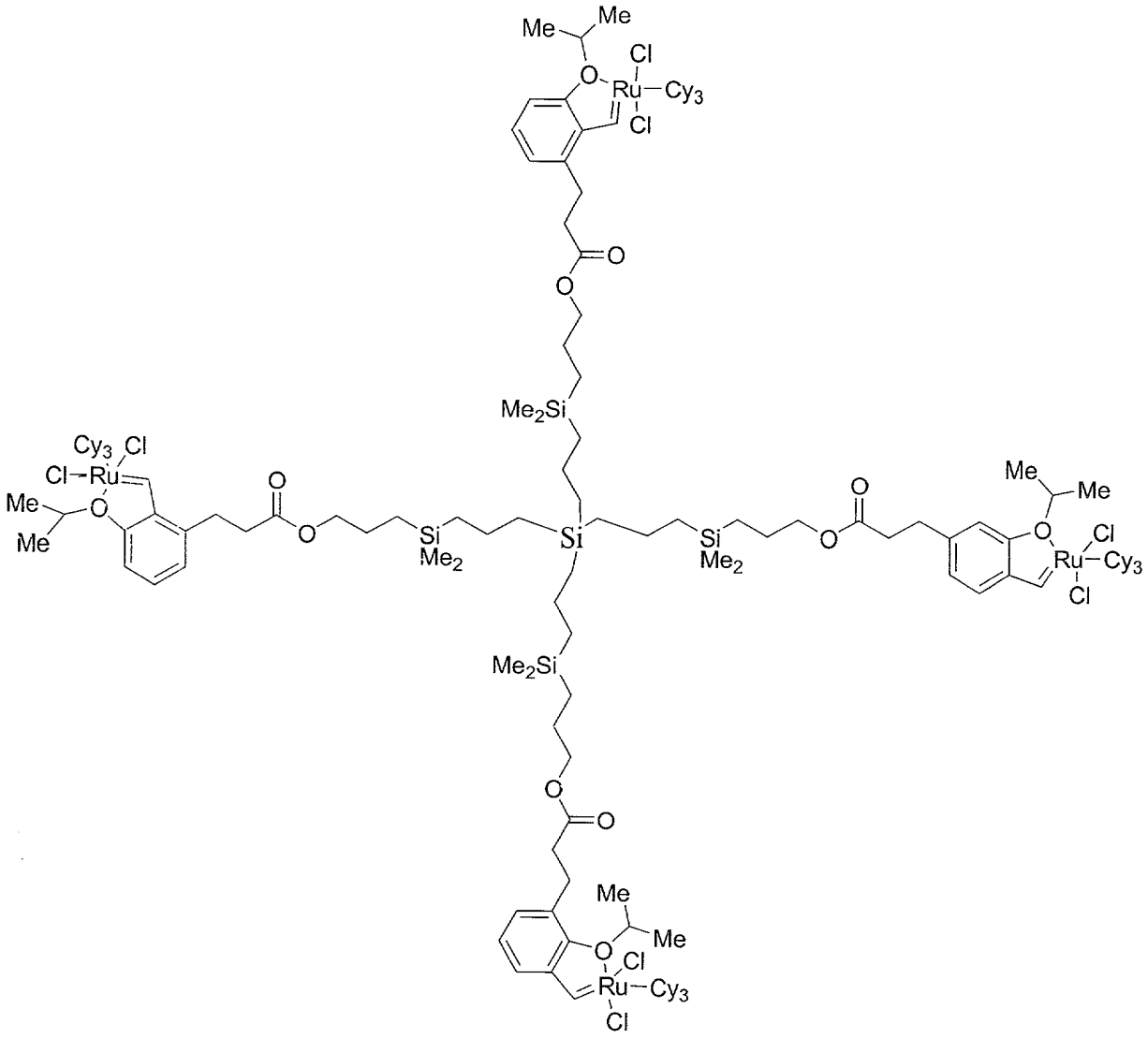
26. The composition of claim 14 wherein Z comprises an aromatic ring structure having the following structure:



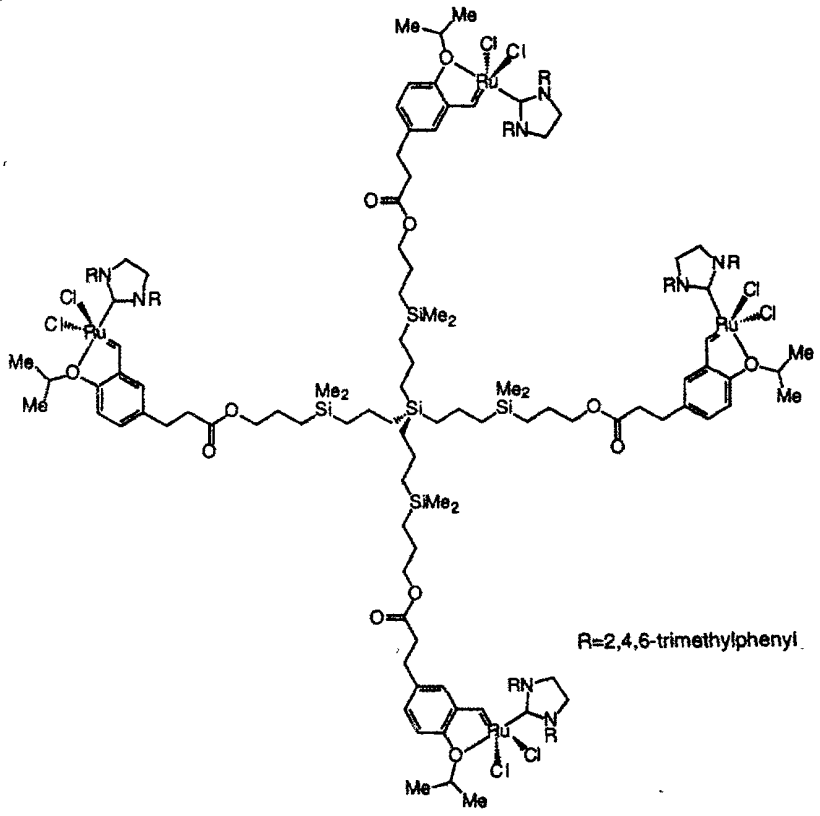
wherein: R_3 and R_4 each comprises an aromatic ring moiety.

27. The composition of claim 26 wherein R_3 and R_4 each comprises 2, 4, 6-trimethylphenyl (mesityl).

28. The composition of claim 14 comprising the following structures:



or



29. The composition of claim 1 wherein the transition metal catalyst is part of a polymeric compound.

30. The composition of claim 1 wherein the transition metal catalyst is chemically bound to a substrate surface.

31. The transition metal catalyst of claim 30 comprising at least one substituent that is capable of reacting with functional groups on the substrate surface so as to render the said catalyst chemically bonded to the said substrate surface.

32. The transition metal catalyst of claim 31 wherein the substituent is selected from the group consisting of alkyl halosilanes, akenyl halosilanes, alkoxy halosilanes, aryloxy halosilanes, aryl halosilanes, akyl halides, cycloalkyl halides, alkenyl halides, cycloalkenyl halides, aromatic

and heteroaromatic halides, acid chlorides, anhydrides, succimidyl esters, epoxides, thiols, acrylate, methacrylate, acrylamide, methacrylamide, benzophenone, and derivatives thereof.

33. The transition metal catalyst of claim 32 wherein the substituent is alkylldimethylsilylcholride.

34. A compositon of claim 1 wherein the said catalyst is capable of chemically bonding to a substrate surface.

35. A composition of claim 30 wherein the substrate is a porous or a non-porous solid phase.

36. A compositon of claim 30 wherein the substrate is glass, metal, non-metal, ceramics, rubber or a polymeric material.

37. A compostion of claim 30 wherein the substrate is part of a containing vessel.

38. A composition of claim 37 wherein the containing vessel is a chemical reactor.

39. A method of immobilizing the transition metal catalyst of claim 1 comprising the steps of

i) reacting the said catalyst with a chemical coupling agent under conditions to form an adduct with said catalyst so as to render it capable of attachment to a substrate surface, and

ii) contacting said adduct with a substrate or a substrate surface under conditions to cause said adduct to become chemically bound to said substrate surface through covalent chemical bonding, ionic bonding, non-ionic interaction, or combinations thereof.

40. A method of claim 39 wherein the catalyst is a transition metal catalyst capable of reacting with a chemical coupling agent that is chemically bonded to a substrate surface.

41. A method of claim 40 wherein the chemical coupling agent comprises a compound containing at least one alkyl halosilanes, akenyl halosilanes, alkoxy halosilanes, aryloxy halosilanes and aryl halosilanes, akyl and cycloalkyl halides, alkenyl and cycloalkenyl halides, aromatic and heteroaromatic halides, acid chlorides, anhydrides, succimidyl esters, epoxides and thiols.

42. The method of claim 41 wherein the chemical coupling agent is allylchloro-dimethylsilane.

43. The method of claim 39 wherein the said transition metal catayst is reacted with a plurality of chemically different coupling agents.

44. The method of claim 39 wherein the substrate is glass, metal, non-metal, ceramics, rubber or a polymeric material.

45. The method of claim 39 wherein the said substrate material is a porous or non-porous material.

46. The method of claim 45 wherein the said substrate material is a porous sol-gel.

47. The method of claim 45 wherein the said substrate material is a solid phase inorganic gel.

48. The method of Claim 47 wherein the said substrate material is a glass mono-lithic gel.